INVESTMENT EVALUATION OF TECHNOLOGY-BASED TRAINING SYSTEMS: TRAINING NEEDS ANALYSIS IN THE ROYAL NORWEGIAN NAVY

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ABSTRACT

This paper describes the results of a research done in the Royal Norwegian Navy into the decision structure of the evaluation process of investing in technology-based training systems. A comprehensive methodology was developed, that evaluates technology-based training systems as information systems. The evaluation method can reveal cost driving training objectives and make sure focus on the strategic value of the information system components is maintained.

INTRODUCTION

The Royal Norwegian Navy (RNoN) is currently evaluating investments in new operational equipment. Investments in technology-based training systems are a part of these investments. The RNoN has developed a cost/benefit analysis method that is particularly suited to evaluate technology-based training systems. The investment evaluations conducted so far have merely focused on the training needs.

A more comprehensive methodology has now been developed, that evaluates technology-based training systems as information systems, and also takes account of their technological and life-cycle consequences. The evaluation method was developed by extensive literature investigation and case studies. The outcome of the case studies was used to improve the decision structure of the evaluation method. This method was developed in a research co-operation between Delft University of Technology in The Netherlands and the Naval Training Establishment HNoMS Tordenskjold in Norway.

TECHNOLOGY-BASED TRAINING SYSTEMS

This term can best be defined by other definitions. An *information system* can be defined as a collection of software, hardware, people, procedures, and data (Brussaard, 1994). Further, an *instructional system* can be defined as an arrangement of resources and procedures used to promote training (Gagné, Briggs, & Wagner, 1992). In this research the context of information systems was within the instructional system where information systems are used to promote training. *Training* is the learning or acquisition of skills, knowledge and attitudes in order to enhance performance at a given task (Burniston & Tayler, 1995).

In this paper the term *technology-based training* implies the use of information systems in any part of the instructional system. To emphasise that an information system is used to promote training, the term chosen is *technology-based training system*. This implies that technology-based training systems must also consist of the five information system components.

Case 1: Communication Trainer

The communication trainer was used in the training of internal and external operational communication procedures. The communication trainer is an integrated part of the existing technology-based training systems at the Naval Training Establishment HNoMS Tordenskjold. The main objectives of the communication trainer are: to take care of all types of training, covering procedures and plans for using existing operational communication equipment. Secondly, internal communication between trainees and trainees/instructor. The third objective was to provide a standard platform for voice communication for existing and future technology-based training systems within the RNoN.

Case 2: Scenario Management System

The scenario management system aims to improve the instructor's working environment by providing the instructor with the required tools for supporting the training process. The system's main objectives were to enable re-design of the instructor function to reduce the number of instructors involved in the training process. Further, it was intended to develop a standard instructor workstation and a prototype of an interconnection device for the Navy's future technology-based training systems.

THE EVALUATION METHOD

The idea behind the *evaluation method*[1] described in this paper is to provide a structured approach to the decision process of investing in technology-based training systems. An analysis of *training needs*, information system *components* and *costs* are required before a decision can be made on what investment strategy to pursue. These analyses are important to prevent overlooking unfavourable consequences in the initial enthusiastic planning phase.

In the context of evaluation of technology-based training systems the term *value* is defined as the sum of associated costs, benefits and risks of the desired competence level and its support technology. In other words, value can be structured into the three components of (1) training domain evaluation, (2) technology domain evaluation and (3) cost evaluation. These evaluations can be done by means of the method outlined in Figure 1. Consequently, to determine the value of different investment strategies requires a structured approach by the RNoN organisation. The different elements of the method (Figure 1) are described in the following sections.

Identify System & Search Space

When a particular problem is perceived, it is of course important to be sure that an associated training need exists. It may be that an apparent need can be satisfied more economically in some other way, for example by a change in the organisation or the introduction of a different personnel policy (Akerjordet, 1993; Patrick, 1992).
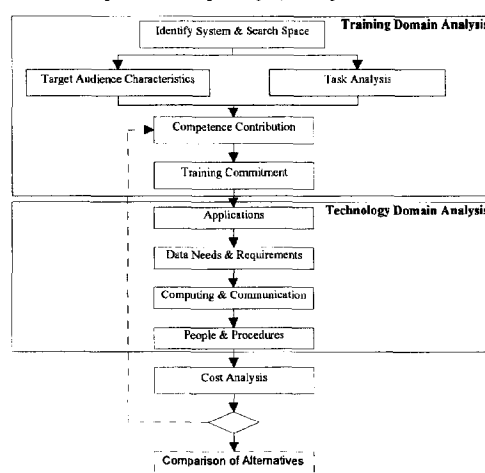

Figure 1. Method for investment evaluation of technology-based training systems (Svendsen, 1996)

Identification of needs, problems, and opportunities are done in order to trace valuable technology-based training system solutions for the organisation (van Reeken, 1994). The identification-process can be carried out on the basis of the information system strategy formulation principle described by Earl (1989). It can be done in three complementary ways: top-down, bottom-up, and inside-out. This process can also be used to evaluate technology-based training system investment strategies. The way this identification process is performed is by means of an approach strategy. The three main *approach strategies* are; (1) clarification of organisational goals, (2) evaluation of existing investments and (3) innovation by application of new technology. A fourth approach strategy is to combine the three strategies in various ways. The strategies of differentiation and focus (Porter, 1985) can be used to further improve the scope of the evaluation approach.

When a discrepancy in the form of a need, problem, or opportunity is identified, further analysis can be undertaken. For this analysis, a mission statement or a project goal must be defined. A mission statement provides a long-term continuity, because it gives the organisation and its employees direction and purpose (Ishoy & Swan, 1992).

Task Analysis

Task analysis is an analysis of the final task for which training is to occur. In other words, it derives the main elements of the training content (Patrick, 1992). Without the task analysis, there can be no guarantee that the training given will not be deficient in some way (ENTWG/TT-PUB 2, 1983). In addition to the analysis of the tasks to be trained, the task analysis must also include the instructor tasks. From the Cases the task space also includes the instructor tasks. By including the instructor tasks in the task space of the planned technology-based training system, a more complete picture of the system can be created.

A *job* is the duties, tasks and sub-tasks performed by one individual (ENTWG/TT-PUB 1, 1990). Where the term *task* is any set of activities occurring at about the same time sharing the same common purpose that is recognisable by the task performer (Patrick, 1992).
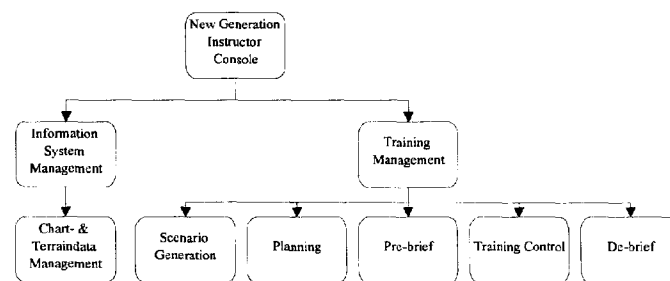

Figure 2. The task hierarchy of the scenario management system

The task can be broken down into *sub-tasks*, which are parts of a task that may not stand alone. When dealing with task analysis it is important to know what is meant by it, and how it is achieved and carried out.
The task analysis technique used in the evaluation method was based on an object-oriented approach (Bots, 1989). This technique is a combination of the critical incident technique (Flangan, 1954), hierarchical task analysis and Petri nets (Kirwan & Einsworth, 1992). The advantage of this object-oriented technique is its descriptive as well as its prescriptive way of illustrating tasks and sub-tasks (Bots, 1989).

Figures 2 and 3 give a high level description of the tasks of the scenario management system of Case 2. Figure 2 illustrates the task space. Figure 3 illustrates the relationship between the different sub-tasks. This object-oriented task analysis technique may help to reduce differences in terminology and create a common ground for understanding evaluating technology-based training systems.

Audience Analysis

Analysis of the trainees will vary from an analysis of main features and down to a detailed analysis of the individual trainee (UD 3-2, 1984). The nature of the trainees must be determined and their skills assessed (ENTWG/TT-PUB 2,

1983). The first decision to be made, is how much information is necessary for an adequate audience identification or analysis. An analogy to conduct an audience analysis is found within product marketing (Moller & McDermott, 1992). Following this idea, the trainees or target audience can be divided into different clusters (Kotler, 1994). Clustering of the target audience can be done after different criteria.

In Case 1 the target audience was clustered after its respective organisations. Some of these organisations were Navy and Coast Guard vessels, and coastal fortresses. These organisations are situated at different locations which implies a target audience scattered
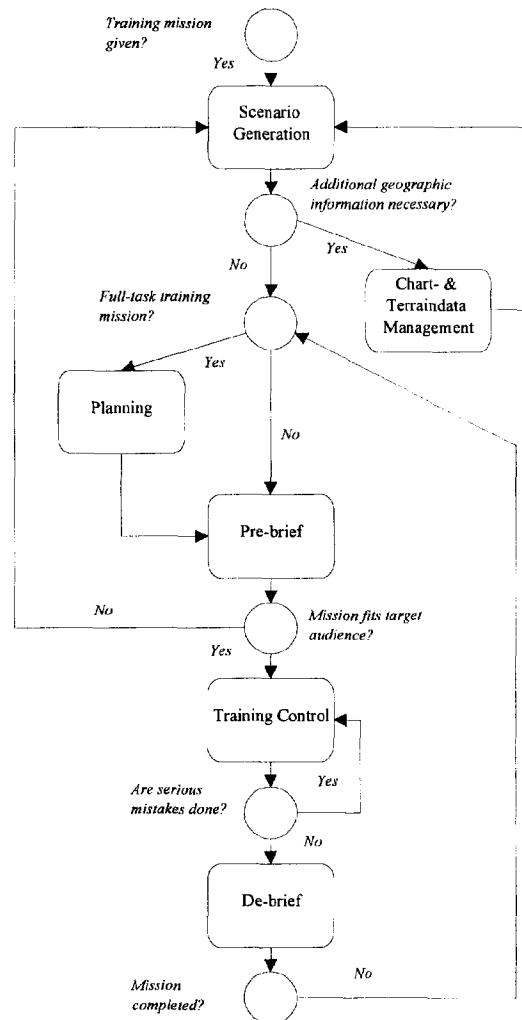

Figure 3. The scenario management task.

over a geographical area. Considerations about the access to different clusters of the target audience must be done when evaluating technology-based training systems.

Further, the target audience can also be clustered after their respective training courses and career programmes. When the clustering of the target audience is done the assessment of the trainees characteristics can be performed.

The target audience analysis will account for the users of the system for which training is to take place. It is necessary to know at what stage the trainees enter the training process (i.e. what skills, knowledge and attitudes they possess prior to

training Burniston & Tayler, 1995). This is important because a technology-based training system can be used for both initial training and continuation training (NIAG(94)SG/45-R4, 1994). In the Royal Norwegian Navy technology-based training systems were applied on three main levels of training. These were the training of (1) individual, (2) team and (3) command operations (RNoN NSST, 1995).

Competence Contribution

Competence is the skills, knowledge and attitudes required to perform an operational task. Different technology-based training systems may differ in meeting operational competence requirements. To evaluate this competence contribution, training objectives have to be defined. A training objective can be seen as an expression that emphasizes what the technology-based training system must be able to support for training to occur. Subsequently, these training objectives are statements of new competencies the trainee should possess at the completion of training to meet operational competence requirements (Russel, Molenda, & Heinich, 1993).

To determine the training objectives structured guidelines are available. One way of detailing training objectives is by means of the convention called the *five-component objective* (Gagné et al 1992). The five-component training objective specifies elements such as the situation, required competence level, specific actions, tools and constraints (Gagné, 1992). Well-defined training objectives are essential when determining the training method to be used.

The training objectives can also be used to gain information on the training system's temporal aspects. In Case 1 the following questions were asked. In what time perspective are the training of these tasks valid? Further, will changes in the operational organisations in the near future have any impact on the training objectives? Temporal analysis is important for the future effectiveness of the technology-based training system.

In addition to the training objectives in Case 1, instructor objectives were defined. The instructor objectives were also a natural element in Case 2, to pinpoint the instructor's needs in the training process. The training and instructor objectives are used to evaluate different technology-based training system investment strategies. The different strategies may range from simple to complex systems solutions.

Training Commitment

Organisational readiness analysis is performed in the Training Commitment stage of the evaluation method. It examines the commitment by the subject matter responsible organisation to implement the proposed technology-based training system into its training programmes.

In Case 1 an important issue was improving the utilisation of existing technology-based training systems within the RNoN. An aspect of this improved utilisation is how the planned technology-based training system fits into the existing and future training courses and programmes. Decisions on including the system in the different training programmes were up to the subject matter responsible organisation and not the service provider department. For the subject matter responsible organisation it can be a question of convenience and practicality before the issue of training effectiveness. Training effectiveness is the best utilisation of resources available in bringing the trainees or target audience up to the required standard (ENTWG/TT-PUB 1, 1990).

Applications

This stage covers the transformation of revealed training and instructor objectives into an environment for application delivery solutions in the form of technology-based training systems.

The man-machine interface (MMI) is the way the trainees and instructors communicate with the technology-based training system. Therefore it is important that the MMI provides the necessary cues for training to occur (Burniston & Taylor, 1995). In the two Cases the MMI were windows-based. In Case 1 the MMI emulated the functionality and presented the image of the operational communication equipment. The purpose-built hardware implemented were the different types of telephones resembling the operational parent equipment. The evaluation of man-machine interface becomes more difficult when considering more complex technology-based training system solutions. Here in addition the MMI can be purpose-built hardware to replicate the operational equipment, as in Case 1. The reproduction of kinaesthetic cues, visual images and audio must also be included.

A technology-based training system may consist of different software modules. In both Cases different system modules were defined such as database management systems (DBMS), scenario generation and simulated entities. Other system modules used in a technology-based training system can be geographical information systems (GIS), and modelling and animation tools. In addition to these software modules the operating system software must also be evaluated. In the two Cases both client and server operating system software were evaluated.

Data Needs & Requirements

Data forms the basis of every information system. The most important issue here is to determine the data structure and the most important data-elements (Eilers, Dijkstra & Hoven, 1991).

In Case 2 a database design was developed to reveal the data foundations required by the system. This database incorporated elements such as scenario descriptions, configuration and model parameters, charts organisation and trainee information. Other data elements considered were charts and terrain information available on standard data formats. Respectively formats such as DX-90, digital terrain elevation data (DTED) and digital feature analysis data (DFAD) (RNoN NSST, 1995).

In Case 1 and Case 2 evaluation of data elements that must be exchanged with other existing or planned technology-based training systems were also undertaken.

Computing & Communication

It is necessary to perform analysis of the required computing architecture of the technology-based training system. This provides an insight into the ability of a particular technology-based training system's architecture to meet performance requirements. The computing architecture of technology-based training systems may range from a collection of elements such as image generators, audio systems, kinaesthetic control systems, specific-purpose built components and scenario management work stations, to personal computers in a network or stand-alone solutions.

In the Cases, both the internal communication network and the external integration with other technology-based training systems were evaluated. In Case 2 the system operated in a distributed environment with a local area network as central communication media. In addition it was supposed to exchange information with other systems by means of a distributed interactive simulation (DIS)-gateway.

People & Procedures

To implement the technology-based training system a set of procedures are required. These procedures or management activities differ with the life-cycle state of the system (Looijen, 1991). In both Cases management procedures were outlined.

In Case 1 the management of the technology-based training system was to be carried out with the existing staffing level. Human recourse evaluations are required for the fulfilment of these management procedures which are necessary to keep the training system operational. The method supports the evaluation of required management procedures and staffing considerations for technology-based training systems.

Cost Analysis

To gain insight into the financial aspects of technology-based training system cost analysis must be undertaken. From the Cases the initial investment cost was identified. Further in Case 1 the life-cycle cost was estimated for the different investment strategies. The initial costs can be divided into two categories (Lien & Bjørn, 1995). First all the costs related to the planning and accomplishment of the project and then the second category covering all the costs concerning the procurement of software, data, hardware and facilities. The life-cycle costs regards all costs associated with the training system's maintenance and management activities.

The effectiveness of a technology-based training system is whether or not it meets well defined objectives that are based on the needs and constraints of its ownership organisation. The method suggested in this paper can be a helpful means to evaluate this effectiveness.

By means of the evaluation method different investment strategies for technology-based training systems can be outlined. These different investment strategies can be illustrated by means of an evaluation matrix (Berghout, 1994). The vertical and horizontal axes portray, respectively, the training and technology value of the investment strategy. The area of the circle reflects the initial and life-cycle cost.
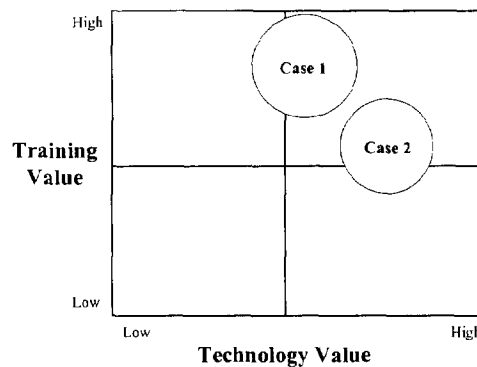

Figure 4. The investment strategy evaluation matrix (Berghout, 1994).

The *training value* of a technology-based training system is its effectiveness, efficiency and relevance to the operational task, as perceived by its users. The *technology value* is the strategic alignment of the information system components with organisational information plans.

Reasons for a more formal approach to investment evaluations of technology-based training systems are:

- The large sums of capital that are often involved in procurement of technology-based training systems.
- Technology-based training systems often have significant consequences for other technology investments, hence compete with other investment opportunities (Hares & Royle, 1994; Berghout, 1994).
- Formal approaches create a common ground for communication between the different parties involved in the decision process.
- Training needs and their technical solutions need to be co-ordinated.
- Increased awareness exists on training objectives and its relevance to the operational situation.
- The initial enthusiasm regarding new products tempt decision makers to overlook possible negative consequences.

The investment analysis technique that has been presented in this paper seems to provide a comprehensive evaluation of technology-based training systems.

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